UNITED STATES PATENT APPLICATION

FOLDED FIN HEAT SINKS

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FOLDED FIN HEAT SINKS

Technical Field

The present invention relates generally to heat sink devices. More particularly, the invention pertains to folded fin heat sinks.

Background Information

Crucial to the relentless progress of information technology is the ability to control a by-product of technology called heat. Given the historical rate of doubling the processing and delivering of information every 18 months, more electrons are being moved about in tighter space and at faster speed. As a result, the heat dissipation requirement has risen proportionally to the advances in information technology. Prior innovations like the extruded heat sink, the die-cast heat sink, and standard fin heat sink have attempted to alleviate the problem, but they all have been unable to accommodate certain requirements of modern systems.

Not one of the above-mentioned heat sinks has the required thermal dissipation rate while accommodating the decrease in the structural geometry of modern devices. The extruded fin heat sink and standard fin heat sink have a similar thermal dissipation capability to each other, but such capability cannot be increased unless a larger size heat sink is used. The die-cast heat sink has an inferior dissipation capability because the manufacturing of these die-cast heat sinks is dependent on the materials that can be used in the molding process. These materials have a poor thermal dissipation capability. Both extruded and die-cast fin heat sinks have less than adequate aspect ratios. The aspect ratio is understood to mean the ratio of fin height to fin thickness. Extruded and die-cast fin heat sinks can boast only a 10:1 ratio, yet the aspect ratio required for dissipating the amount of thermal energy generated in modern devices may be greater. The standard fin heat sink seems to be constrained in its ability to expose only some of its surfaces to the

convection medium. So, it too does not provide the dissipation needed by modern devices.

Thus, what is needed is a heat sink that inhibits deterioration in the performance of electronic devices due to the presence of heat or thermal energy.

Summary

An illustrative embodiment of the invention ~~describes~~ includes a heat sink comprising a number of laterally placed planar fins forming from a single sheet. The number of laterally placed planar fins define a folded fin structure. The top of at least one fin of the folded fin structure is modified to form an opening to receive a convection medium. The heat sink also includes a base that is attached to the bottom of the folded fin structure.

Another illustrative embodiment ~~describes~~ provides a method of manufacturing a heat sink. The method includes creating a number of openings placed at predetermined intervals on a sheet, folding the sheet in an accordion fold to form a number of laterally placed fins, and attaching a base to the bottom of the number of laterally placed fins.

Brief Description of the Drawings

Figure 1 is an exploded isometric view showing a heat sink in accordance with one embodiment of the present invention.

Figure 2 is an assembled isometric view showing a heat sink in accordance with one embodiment of the present invention.

Figure 3 is a front view showing a heat sink in accordance with one embodiment of the present invention.

Figure 4 is a side view showing a heat sink in accordance with one embodiment of the present invention.

Figure 5 is a cross-sectional view of a heat sink in accordance with one embodiment of the present invention.

embodiment of the present invention.

Figure 6 is a view of the flow of the convection medium of a heat sink in accordance with one embodiment of the present invention.

Figure 7 is a close-up view of a base of a heat sink in accordance with one embodiment of the present invention.

Figure 8 is a front view showing a heat sink in accordance with one embodiment of the present invention.

Figure 9 is a close-up view of a bend of the fins of a heat sink in accordance with one embodiment of the present invention.

Figure 10 is a view of a flat stock metal sheet according to one embodiment of the present invention.

Detailed Description

In the following detailed description of the invention, reference is made to the accompanying drawings that form a part hereof, and in which are shown, by way of illustration, specific embodiments in which the invention may be practiced. In the drawings, like numerals describe substantially similar components throughout the several views. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments may be utilized and structural, logical, and electrical changes may be made without departing from the scope of the present invention.

Figure 1 is an exploded isometric view showing a heat sink 100 in accordance with one embodiment of the present invention. The heat sink 100 includes fins 110. The fins 110 allow an increase in surface area for thermal dissipation without increasing the overall volume taken by the heat sink 100.

Increasing surface area for a given volume is important in heat sinks. This is because the rate at which the heat sink can cool a device having thermal energy is proportional to the surface area of the heat sink. Thus, dissipation rate is dependent

on space in this relationship; hence, to increase the rate of cooling requires an increase in the area from which cooling can take place. Modern electronic devices have high thermal dissipation requirements, but these devices also have decreasing footprints.

Returning to Figure 1, the fins 110 are formed from a flat stock metal sheet. The sheet is made out of materials that are thermally conductive. In one embodiment, the material is a thermally conductive plastic. In another embodiment, the stock sheet is made out of copper. In another embodiment, the stock sheet is made out of aluminum. In another embodiment, the fins 110 are made from a compound containing copper. In a further embodiment, the fins 110 are made from a compound containing aluminum.

The fins 110 have a first set of bends 112 and a second set of bends 114. The set of bends 112 is modified to have a set of openings 116. In one embodiment, the set of openings 116 is created after the fins have been formed from the flat stock metal sheet. In another embodiment, the set of openings 116 is created on the flat stock metal sheet prior to forming the fins 110. The set of openings 116 allows a convection medium, such as air, to flow vertically into the fins 110.

The fins 110 have a number of planar surfaces 118 and a front 117. The set of bends 112 and 114 define the top and bottom of the fins 110, respectively. The top of the fins 110 is attached to a fan 120, in one embodiment. In another embodiment, the fan is attached to the front of the fins 110. In a further embodiment, one fan 120 is attached to the top of the fins 110 while another fan is attached to the front of the fins 110.

The fan 120 introduces a convection medium, such as air, to the ~~heat sink 100~~ fins 110. In one embodiment, the convection medium is introduced to each surface of the planar surfaces. In another embodiment, the convection medium is introduced to greater than fifty percent of the planar surfaces.

The bottom of the fins 110 is attached to a base 130. Various embodiments of how the fins 110 attach to the base 130 are discussed below. In one embodiment, the base

130 is solid. In another embodiment, the base 130 is a chamber. In another embodiment, the base is made from aluminum. In another embodiment, the base is made from copper. In another embodiment, the base is made from a compound containing aluminum. In yet another embodiment, the base is made from a compound containing copper. In a further embodiment, the base is made from manufactured diamond.

Figure 2 is an assembled isometric view showing the heat sink 100 in accordance with one embodiment of the present invention. The top of the fin structure 110 as defined by the set of bends 112 is attached to a fan 120. In one embodiment, another fan is attached to the front 117. The fan 120 forces a convection medium to flow parallel to the fin structure. The other fan attached to the front 117 forces a convection medium to flow parallel to the base 130. However, in another embodiment, the fan 120 attaching to the top of the fin structure is sufficient to guide the convection medium to flow parallel to the fins as well as parallel to the base. These two parallel flows carry more thermal energy than either one alone.

Aspect ratio is a measurement in thermal management that is indicative of fin height to fin thickness. In other words, it is an efficiency measurement regarding the number of surfaces available for the dissipation of heat against the space taken up by the heat sink device. The heat sink device as described in the above and below embodiments has an aspect ratio between about 20:1 to 30:1.

Figure 3 is a front view showing the heat sink 100 in accordance with one embodiment of the present invention. In one embodiment, the bottom of the fin bundle 110 is bonded to the base 130 through a brazing process. In another embodiment, the bottom of the fin bundle is bonded to the base by application of an epoxy. In another embodiment, the bottom of the fin bundle is bonded to the base by soldering. In a further embodiment, the bottom of the fin bundle is thermally clamped to the base by at least one clip.

Figure 4 is a side view showing the heat sink 100 in accordance with one embodiment of the present invention. The fan 120 introduces a convection medium to flow through the openings 116 to reach the base 130. The convection medium takes up the thermal energy transferred through the base 130 and carries it parallel to and out of the base 130.

Figure 5 is a cross-sectional view of the heat sink 100 in accordance with one embodiment of the present invention. Figure 5 is a cross-sectional view of Figure 4. A flat stock metal sheet is creased to form fins 110 with an accordion configuration. The top of the fins 110 has a number of bends 112. These bends 112 are trimmed to reveal a number of openings 116. The top of the fins 110 is attached to the fan 120. The bottom of the fins 110 is attached to the base 130.

The surface 534 of the base receives thermal energy generated from electronic components (not shown). Electronic components interface with the heat sink 100 through the surface 534 of the base 130. Thermal energy received at the surface 534 is conducted throughout the base. Subsequently, the thermal energy is presented at surface 532. The fins 110 then conduct the presented thermal energy at surface 532 throughout the number of surfaces 118 of the fins 110. The thermal energy on the number of surfaces 118 is transferred onto a convection medium 522 flowing parallel to the number of surfaces 518. The convection medium 522 engages the number of surfaces 518 by flowing down each natural opening of the fins 110 as well as the trimmed openings 116 of the fins 110. The convection medium now carries the transferred energy down toward the base 130. Once the convection medium 522 engages the base 130, the convection medium 522 turns about 90 degrees and flows parallel to the base 130 (into and out of the page of Figure 5). As the convection medium turns, it picks up more thermal energy from the base 130 and carries the thermal energy away into the ambient environment of the heat sink 100.

The fan 120 is responsible for introducing the convection medium 522 to the fins 110. The trimmed bends 112 of the fins 110 allow more thermal energy to be exposed to the

convection medium 522. For illustrative purposes only, the fan introduces another convection medium 524 to the fins 110. Without the trimming technique of the described embodiments, the convection medium 524 engages only a portion of the number of surfaces 518. Thus, less thermal energy can be transferred to the convection medium 524. In contrast, the convection medium 522 can flow through the natural openings 116 of fins and also through the trimmed openings of the fins 110. Therefore, with the application of the trimming technique, more thermal energy can be carried away before it diminishes the performance of electronic components.

Figure 6 is a view of the flow of the convection medium of a heat sink in accordance with one embodiment of the present invention. Figure 6 is a front view of the heat sink as presented in isometric form in Figures 2 and 4.

The fan 120 introduces a convection medium 640 into the fins 110. The convection medium 640 flows parallel to the plurality of surfaces of the fins 110. Once the convection medium 640 engages the base 130, it turns about 90 degrees to seek an exit from the fins 110 and flows parallel to the base. The described flow mechanics of the convection medium 640 turns out to carry a large amount of thermal energy.

The reason the convection medium 640 carries more thermal energy is because the 90 degree turn incidents the convection medium upon a thin boundary layer of thermal energy on the surface of the base 130. More energy is transferred in such a boundary layer than with a thicker boundary layer.

Figure 7 is a close-up view of the base 730 of the heat sink 100 in accordance with one embodiment of the present invention. The base 730 defines a chamber 740. In one embodiment, the chamber 740 is a vacuum. The chamber 740 is partially filled with a small quantity of aqueous solution 750. In one embodiment, the aqueous solution 750 is water.

Electronic devices interface with the heat sink 100 at the surface 734. At that interface, electronic devices (not shown) transfer thermal energy to the surface 734. The thermal energy at the surface 734 excites the aqueous solution 750. Such excitation transforms a

portion of the aqueous solution 750 to a gaseous state 752. Functionally, thermal energy at surface 734 is transferred to the gaseous state 752 when the aqueous solution shifts state from liquid to gas.

The gaseous state 752 rises to the top of the chamber 740. Here, The gaseous state 752 encounters the cooler surface at the top of the chamber. The gaseous state 752 shifts to liquid state 754 and condenses at the top of the chamber 740. The thermal energy in the liquid state 754 is transferred to the surface 732. The liquid state 754 then travels back to the bottom of the chamber 740 where it rejoins the aqueous solution 750.

The thermal energy at the surface 732 is carried away by the convection medium introduced by fan 120 into the fin structure 110.

Figure 8 is a front view showing the heat sink 100 in accordance with one embodiment of the present invention. In one embodiment, the fins are fixedly attached to the base 130 through at least one clip 860_0. In another embodiment, clip 860_1 is used together with clip 860_0 to hold the fins to the surface 132 of base 130. In yet another embodiment, a layer of thermal gel is deposited between the set of bends 114 and the surface 132. Other embodiments may include thermal grease, epoxy, phase-changed material, or thermal interface material. This layer of thermal gel facilitates better transfer of thermal energy away from the base to the fins.

Figure 9 is a close-up view of a bend of the fins of a heat sink in accordance with one embodiment of the present invention. Bend 900 is situated laterally adjacent to other bends 906_0 and 906_1. Bends 900, 906_0 and 906_1 are created from folding a sheet to form the fins of the heat sink. Bend 900 includes an arch 902. Bend 900 also includes supporting walls 905_0 and 905_1.

In one embodiment, the arch is defined by the radius 904_0, 904_1, and 904_2 measuring from the focus ~~906~~ 908. The arch is removed to allow a convection medium to enter the space underneath the arch. In another embodiment the arch and a portion of the support walls 905_0 and 905_1 are removed.

Standard fin heat sinks allow the convection medium to flow through the

natural opening between the bends 900 and 906_0, and the bends 900 and 906_1. The present embodiment not only allows the convection medium to flow in the natural openings but also guides the convection medium to flow inside the bend 900 (underneath the arch). By opening up the bend 900, the present embodiment essentially increases the surface area by which thermal energy can be carried away within the same heat sink dimensions.

Figure 10 is a view of a flat stock metal sheet 1000 according to one embodiment of the present invention. This sheet 1000 is used to manufacture the fins as described above. The sheet 1000 has a width 1002 and a height 1003. It also has a certain thickness. These dimensions are chosen so as to satisfy two criteria. First, the dimension of the sheet 1000 is chosen to accommodate the thermal dissipation requirement of a device. Second, the dimension is chosen so that the heat sink can be compatible with the footprint or height requirements of the device.

The sheet 1000 has a number of creases 1006_0, 1006_1, 1006_2, ..., 1006_N. For a given width and height dimension, these creases define a fin pitch dimension. the fin pitch is understood to mean to distance between a centerline of one fin to the centerline of an adjacent fin. In the manufacturing process of the fins, these creases are bent so as to form an accordion fold.

The sheet 1000 also has a number of openings 1004_0, 1004_1, 1004_2, ..., 1004_N (collectively "openings 1004"). These openings 1004 are created at predetermined intervals on the sheet 1000. In one embodiment, these openings 1004 are rectangular in shape. In another embodiment, these openings 1004 are oval in shape. In another embodiment, the openings are created through a progressive or continuous stamping operation before the creases are bent to form the fins. In yet another embodiment, the fins are formed and then an End-mill is used to route the number of openings 1004. In a further embodiment, the fins are formed and then a fly cutter is used to create the openings 1004.

Conclusion

A heat sink has been described that inhibits thermal deterioration in the performance of devices. The embodiments of the heat sink described above dissipate more thermal energy in accordance with the requirements of modern devices. Because the embodiments of the heat sink as described above can accommodate the dual requirements of thermal dissipation and modern structural constraints, the heat sink can be used in diverse devices, such as power systems, mobile applications, and server environments.

Although the specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that any arrangement which is calculated to achieve the same purpose may be substituted for the specific embodiment shown. This application is intended to cover any adaptations or variations of the present invention. It is to be understood that the above description is intended to be illustrative and not restrictive. Combinations of the above embodiments and other embodiments will be apparent to those of skill in the art upon reviewing the above description. The scope of the invention includes any other applications in which the above structures and fabrication methods are used. Accordingly, the scope of the invention should only be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled.